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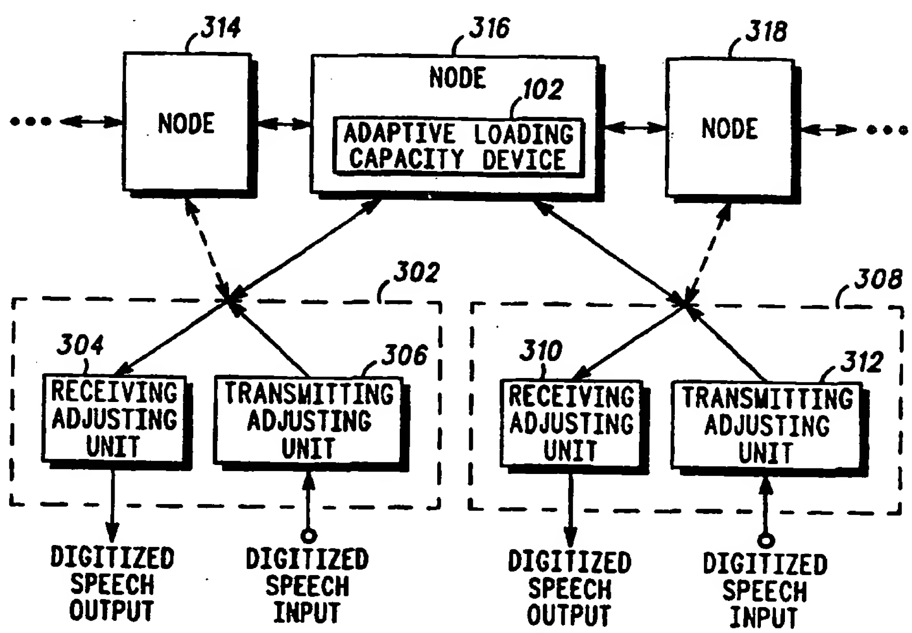
(54) Title: DEVICE AND METHOD FOR ADAPTIVELY ADJUSTING LOADING CAPACITY FOR A NODE IN A PACKETIZED COMMUNICATION SYSTEM



(57) Abstract

Flow of digitized coded speech packets through virtual circuits in a multi-node communication system (300) is controlled by an adaptive loading capacity device (102) in the nodes (314, 316, 318). The adaptive loading capacity device (102) determines an adjusted throughput data rate ATDR (602, 604) for a node (314, 316, 318) that is substantially equivalent to a predetermined upper limit of the system's capacity. When a requested data rate value RDR included in a frame (200) is greater than the ATDR, the device automatically adjusts the RDR downward to substantially equal the ATDR (702, 704) and incorporates the adjusted RDR into frames (200) transmitted to coupled nodes (314, 316, 318) and stations (302, 308).

DEVICE AND METHOD FOR ADAPTIVELY ADJUSTING LOADING CAPACITY FOR A NODE IN A PACKETIZED COMMUNICATION SYSTEM

Field of the Invention

The present invention relates generally to capacity in a communication system. More particularly, the present invention relates to a device and method for adjusting loading capacity in a packet-based communication system.

Background

Communication resources such as radio frequency channels have a limited capacity. Nevertheless, communication needs have continued to increase. More users are continually being added to communication systems. The efficiency and reliability of a communication system is closely related to its system capacity. System capacity is generally based on the number of available channels and the throughput rate associated therewith. Without technical improvements that provide for loading capacity adjustment, users may face impaired service, or ultimately, a complete lack of available service.

Trunked communication systems such as telephone and cellular systems typically include an inherent fixed upper threshold for system capacity. In a digital communication system, this upper threshold is an upper limit that is based on the number of available channels and the throughput rate. When the upper limit of the system's capacity is reached, the system is unable to carry data traffic (i.e., call blocking occurs). For a fixed bandwidth digital communication system, typically maximum throughput is limited to a predetermined

upper limit that is allowed for a channel. In addition, for a voice channel, if more throughput is allocated to digital representation of voice on the channel, fewer channels can be simultaneously utilized. As traffic on the system increases to a level that approaches the fixed upper limit of the system's capacity, if no flexibility is provided for adjusting the traffic-carrying capacity of the system, call blocking is highly likely to occur.

Thus, there is a need for an adaptive capacity loading device and method for providing a more efficient communication system by lowering the probability of call blocking as call traffic approaches the upper limit of the system's capacity.

Summary of the Invention

An adaptive loading capacity device for a node and a method for adaptively adjusting a loading capacity for a node are set forth. The device automatically adjusts a data rate of a vocoder for the node in a packet-based linked communication system. The device includes a data traffic-determining unit, operably coupled to receive data traffic, for determining whether a current data rate (CDR) of the data traffic within the node exceeds a predetermined threshold and, where the CDR exceeds the predetermined threshold, for determining an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with a predetermined strategy such that further links/station(s) may utilize the system. The data traffic includes frames that include packetized information for coded speech data traffic. Frames also include a requested data rate (RDR) and a current data rate (CDR) for the coded speech data traffic. The device further includes an automatic adjusting unit operably coupled

to the data traffic-determining unit for, upon comparing the RDR with the ATDR and determining that the RDR is greater than the ATDR, automatically adjusting the RDR downward to equal the ATDR. In this manner system capacity is increased, and a probability of call-blocking is reduced in the system.

The method implements the functions of the device as described above.

Brief Descriptions of the Drawings

FIG. 1 is a block diagram of a first embodiment of an adaptive loading capacity device in accordance with the present invention.

FIG. 2 illustrates a frame format for basic information contained within a frame in the system in accordance with the present invention.

FIG. 3 is a block diagram of an adaptive loading capacity device for a node together with a plurality of stations in a packet-based communication system in accordance with the present invention.

FIG. 4 is a block diagram showing a station of FIG. 3 with greater particularity.

FIG. 5 is a block diagram of a communication system utilizing an adaptive capacity loading device in accordance with the present invention.

FIG. 6 is a flow chart setting forth a first embodiment of steps in accordance with the method of the present invention.

FIG. 7 is a flow chart illustrating the step of automatically adjusting the RDR downward to equal the ATDR of FIG. 6 is shown with more particularity.

FIG. 8 is a flow chart setting forth a second embodiment of steps of the method of the present invention.

FIG. 9 is a block diagram of a microprocessor constructed and arranged (programmed) to provide the adaptive loading capacity device of the present invention.

Detailed Description of a Preferred Embodiment

The present invention provides an device and method that readily identifies a coded speech data rate loading problem at a node in a communication system where the loading may lead to call blocking due to filling of the system capacity. Then, the present invention automatically reduces the coded speech data rate, thereby reducing the data rates available for additional calls that may be added to the system. This action allows subsequent calls to be placed without call blocking, allowing more calls at a reduced voice quality during periods of heavy traffic.

FIG. 1, numeral 100, is a block diagram of a first embodiment of an adaptive loading capacity device in accordance with the present invention. The adaptive loading capacity device (102) automatically adjusts a data rate of a vocoder for a node in a packet-based linked communication system. The device includes a data traffic-determining unit (104) and an automatic adjusting unit (106).

The data traffic-determining unit (104) of the node is operably coupled to receive data traffic of the communication

system, generally from multiple nodes and, where selected, at least one of a plurality of stations. A station is an input/output point of the communication system, i.e., generally a single addressable site on a LAN that is typically implemented as a computer and selected peripherals. The data traffic-determining unit (104) determines a current data rate (CDR) of data traffic within the node and determines whether the CDR exceeds a predetermined threshold. The predetermined threshold is an upper rate limit for the system. Where the CDR exceeds the predetermined threshold, the data traffic-determining unit (104) determines an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with a predetermined strategy. The strategy is to provide an adjusted rate that is lower than the current rate, thereby allowing the node to throughput data traffic for a greater number of calls. The ATDR typically represents an upper rate limit or capacity of the system or, alternatively, an upper rate limit decremented by a buffer value. The buffer value prevents a slight increase in data rate from filling the capacity of the system, causing call-blocking.

Data traffic is packetized into frames that include a requested data rate (RDR). The strategy implemented includes comparing the magnitudes of the RDR and the ATDR and reducing the RDR to the ATDR. Thus, where a RDR of a frame is greater than the ATDR, the device automatically adjusts the RDR downward to substantially equal the ATDR. The adjusted RDR is incorporated into frames that are transmitted to coupled nodes and stations, which then automatically adjust the CDR to substantially equal the requested RDR. The reduction of the CDR allows further links/station(s) to utilize the system.

As illustrated in FIG. 2, numeral 200, the data traffic comprises frames that include packetized information for coded speech data traffic (208). The frames further include a requested data rate (RDR) (204) and a current data rate (CDR) (206) for the coded speech data traffic. In addition, each frame typically includes a frame descriptor (202). The coded speech data traffic comprises packets of digitized code that represent speech information from calls made by communication system users.

The automatic adjusting unit (106) is operably coupled to the data traffic-determining unit (104). The automatic adjusting unit (106) compares the RDR of each frame with the ATDR received from the data traffic-determining unit (104) and determines whether the RDR is greater than the ATDR. Where the RDR is greater than the ATDR, the automatic adjusting unit (106) automatically adjusts the RDR downward to equal the ATDR. Where the RDR is less than or equal to the ATDR, the automatic adjusting unit (106) typically maintains the current RDR. Where the RDR is adjusted to a lower rate (i.e., the ATDR is less than the RDR), the probability of call-blocking is reduced since a portion of the capacity of the system becomes available for additional calls. The adjusted RDR is incorporated into frames that are transmitted to coupled nodes and stations, which then automatically adjust the CDR to substantially equal the requested RDR. Clearly, there is some loss of voice quality in the received transmissions, but the loss is typically acceptable and call-blocking is reduced.

FIG. 3, numeral 300, is a block diagram of an adaptive loading capacity device of a node where a plurality of nodes function together with a plurality of stations in a packet-based communication system in accordance with the present invention. FIG. 4, numeral 400, is a block diagram showing a

station of FIG. 3 with greater particularity. The adaptive loading capacity device (102), as described more fully above, is coupled to transmit and receive packetized coded speech data traffic from a plurality of nodes (314, 316, 318, ...) and stations (302, 308, ...). Each station includes a receiving-adjusting unit (304, 310, ...), operably coupled to a at least a first node for, upon receiving a frame of packets of coded speech data traffic from the node (102, ...), sending a received RDR of the frame to an encoding-initializing unit (406) of the station and decoding the packets at a rate defined by the CDR of the frame. Each station also includes a transmitting-adjusting unit (306, 312, ...) that is operably coupled to the node (102, ...) for receiving digitized speech data, encoding said data into packets and transmitting the encoded speech packets at the RDR that has been adjusted to be substantially equivalent to the received RDR. It should be noted, for example, that in an implementation in which each of the nodes is located in a separate orbiting satellite of a plurality of satellites, typically a station receives frames of packets from, and transmits frames of packets to, a satellite that is predetermined with respect to its orbital position. That is, generally a station will receive/transmit at least from/to the orbiting satellite that is in greatest proximity to the station. Also, it is clear that, with respect to system capacity, where the station detects a highly loaded node, as predetermined, the station may further make an adjustment to receive/transmit from/to another node.

The transmitting-adjusting unit (306, 312, ...) typically includes an encoding-initializing unit (402), a data rate setting unit (404), and a transmitting unit (406). The encoding-initializing unit (402), operably coupled to receive digitized speech input and to the receiving-adjusting unit (304), encodes and packetizes the digitized speech packets

utilizing the CDR and initializes an RDR of frames to be equivalent to the received RDR.

The data rate setting unit (404) is operably coupled to the encoding-initializing unit (402) and is utilized for setting the CDR of the frame to the requested RDR for the station and inserting the CDR and RDR into the frames.

The transmitting unit (406) is operably coupled to the data rate setting unit (404), for transmitting the frames to a preselected node.

FIG. 5, numeral 500, is a block diagram of a communication system utilizing a first embodiment of an adaptive capacity loading device in accordance with the present invention. In the first embodiment a plurality of nodes (node 1, node 2, node 3, ...) are operably coupled, as preselected, and a plurality of stations (Station 1, 516; Station 2, 518; Station 3, 520; Station 4, 522, ...) are operably coupled to at least one of the nodes such that each station has a communication path with other stations in the system. In the embodiment, each of the nodes (504, 506, 508, ...) includes an adaptive capacity loading device (ACDL) (510, 512, 514, ...) that operates as described above. Clearly, in an alternate embodiment, a system may be arranged so that only nodes that are more likely to experience high traffic rates include the device of the present invention. By determining an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with the predetermined strategy described above, further links/station(s) may utilize the system.

It is to be understood that the couplings of the communication system may accommodate frames/packets of data traveling in both directions. The frames may carry data

packets and acknowledgement packets for many different calls or virtual circuits. Thus, each line may be considered as constituting many different paths for accommodating many different calls from many different stations.

FIG. 6, numeral 600, is a flow chart setting forth a first embodiment of the steps in accordance with the method of the present invention. The method of the invention provides for automatically adjusting a data rate of data traffic of a vocoder for a node in a packet-based linked communication system, where the data traffic comprises packets that include at least information for coded speech data traffic and frames that include a requested data rate (RDR) and a current data rate (CDR) for the coded speech data traffic.

The method shown in FIG. 6 includes the step of first determining whether a current data rate (CDR) of the data traffic within the node exceeds a predetermined threshold (602) and, where the CDR exceeds the predetermined threshold, determining an adjusted throughput data rate (ATDR) (604) for links/station(s) utilizing the system in accordance with a predetermined strategy such that the system may accommodate traffic for further calls. The predetermined strategy includes provision of an adjusted rate to a node where the adjusted rate is lower than the current rate, thereby allowing the node to throughput data traffic for a greater number of calls. An RDR of each received frame is compared with the ATDR. Where the received RDR is greater than the ATDR, the RDR is automatically adjusted downward to be substantially equal to the ATDR. Thus, for example, as illustrated in FIG. 7, numeral 700, the step of automatically adjusting the RDR downward to equal the ATDR (FIG. 6) includes reducing the RDR to an ATDR that is equivalent to one of: a predetermined upper limit of the system's capacity (702) and the predetermined upper limit of the system's capacity

minus a predetermined buffer value (704). The adjusted RDR is incorporated into frames that are transmitted to coupled nodes and stations, which then automatically adjust the CDR of received frames to substantially equal the requested RDR. In this manner, a probability of call-blocking is reduced in the system.

FIG. 8, numeral 800, is a flow chart setting forth a second embodiment of the steps of the method of the present invention. In the second embodiment, the method further includes implementation of the following steps by the stations: (1) upon receiving a frame of coded speech data traffic from a node, sending a received RDR of the frame to an encoding-initializing unit of the transmitting-adjusting unit of the station and also decoding packets of the frame at the CDR (802), and (2) transmitting an encoded speech frame (804) by (A) encoding and packetizing the digitized speech data utilizing the CRC and initializing the RDR of the frame to be substantially equivalent to the received RDR (806); (B) setting the CDR to the received RDR and inserting the CDR and the received RDR into the frame (808); and (C) transmitting the frame to a preselected node (810).

Though hardware embodiments have been discussed, each of the elements of the hardware can be alternatively implemented by incorporation of the steps of the method, FIGs. 6-8, which clearly implement the functions of the hardware, in a computer program.

FIG. 9, numeral 900, is a block diagram of a microprocessor constructed and arranged (programmed) to provide the adaptive loading capacity device of the present invention. The microprocessor (902) is programmed to provide at least the functions of the data traffic-determining unit (104) and the automatic adjusting unit (106), as described

above. The device further includes, associated memory circuitry (904), and associated circuitry for coupling the microprocessor to the node(s) (906) and to receive data traffic from the stations/nodes (908,...).

Although exemplary embodiments are described above, it will be obvious to those skilled in the art that many alterations and modifications may be made without departing from the invention. Accordingly, it is intended that all such alterations and modifications be included within the spirit and scope of the invention as defined in the appended claims.

We claim:

1. An adaptive loading capacity device for automatically adjusting a data rate of a vocoder for a node in a packet-based linked communication system, comprising:

1A) data traffic-determining unit (104), operably coupled to receive data traffic, for determining whether a current data rate (CDR) of the data traffic within the node exceeds a predetermined threshold and, where the CDR exceeds the predetermined threshold, determining an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with a predetermined strategy such that further links/station(s) may utilize the system;

1B) automatic adjusting unit (106)operably coupled to the data traffic-determining unit for, where the data traffic comprises frames that include packetized information for coded speech data traffic, a requested data rate (RDR) for the coded speech data traffic, and a current data rate (CDR) for the coded speech data traffic,

comparing the RDR of each frame with the ATDR , determining whether the RDR is greater than the ATDR and, where the RDR is greater than the ATDR, automatically adjusting the RDR downward to equal the ATDR,

such that a probability of call-blocking is reduced in the system.

2. The device of claim 1 wherein the frames each further include a frame descriptor.

3. The device of claim 1 wherein the predetermined strategy includes provision of an adjusted rate to the node where the adjusted rate is lower than the current rate and the ATDR is equivalent to one of:

3A) a predetermined upper limit of the system's capacity;

3B) the predetermined upper limit of the system's capacity minus a predetermined buffer value.

4. The device of claim 4 wherein the device includes a microprocessor that is programmed to provide the functions of the data traffic-determining unit and the automatic adjusting unit, associated memory circuitry, and associated circuitry for coupling the microprocessor to the node(s) and to receive data traffic from the station(s).

5. A method for automatically adjusting a data rate of data traffic of a vocoder for a node in a packet-based linked communication system where the data traffic comprises frames that include packetized information for coded speech data traffic, a requested data rate (RDR) for the coded speech data traffic, and a current data rate (CDR) for the coded speech data traffic, comprising the steps of:

5A) determining whether a current data rate (CDR) of the data traffic within the node exceeds a predetermined threshold (602) and, where the CDR exceeds the predetermined threshold, determining an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with a predetermined strategy such that further links/station(s) may utilize the system;

5B) comparing the RDR of each packet with the ATDR , determining whether the RDR is greater than the ATDR and, where the RDR is greater than the ATDR (604), automatically adjusting the RDR downward to equal the ATDR,

such that a probability of call-blocking is reduced in the system.

6. The method of claim 5 wherein at least one of 6A-6B:

6A) the frames each further include a frame descriptor, and

6B) the predetermined strategy includes provision of an adjusted rate to a node where the adjusted rate is lower than the current rate and the ATDR is equivalent to one of 6B1-6B2:

6B1) a predetermined upper limit of the system's capacity; and

6B2) the predetermined upper limit of the system's capacity minus a predetermined buffer value.

7. A method for automatically adjusting a data rate of data traffic of a vocoder for a node in a packet-based linked communication system with a plurality of stations where the data traffic comprises frames that include at least packetized information for coded speech data traffic, a requested data rate (RDR) for the coded speech data traffic, and a current data rate (CDR) for the coded speech data traffic, comprising the steps of:

7A) determining whether a current data rate (CDR) of the data traffic within the node exceeds a predetermined threshold and, where the CDR exceeds the predetermined threshold, determining an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with a predetermined strategy such that further links/station(s) may utilize the system;

7B) comparing the RDR of each packet with the ATDR , determining whether the RDR is greater than the ATDR and, where the RDR is greater than the ATDR, automatically adjusting the RDR downward to equal the ATDR,

such that a probability of call-blocking is reduced in the system,

and wherein the stations implement the following steps:

7C) upon receiving a frame having packets of coded speech data traffic from the node, sending a received RDR to an encoding-initializing unit of the station and decoding the packet at a rate defined by the CDR of the frame; and

7D) for transmitting an encoded speech frame:

7D1) encoding and packetizing digitized speech data utilizing the CDR and for initializing an RDR of the frame to become substantially equivalent to the received RDR;

7D2) setting the CDR to the RDR and inserting the CDR and RDR into the frame; and

7D3) transmitting the frame to a preselected node.

8. The method of claim 7 wherein at least one of 8A-8C:

8A) the frames each further include a frame descriptor,

8B) the predetermined strategy includes provision of an adjusted rate to a node where the adjusted rate is lower than the current rate and the ATDR is equivalent to one of 8B1-8B2:

8B1) a predetermined upper limit of the system's capacity; and

8B2) the predetermined upper limit of the system's capacity minus a predetermined buffer value, and

8C) the steps of the method are implemented in a computer program.

9. A packet-based linked communication system comprising a plurality of stations and at least a first node having a data rate adjusting device for automatically adjusting a data rate of data traffic of a vocoder for the node where the data traffic comprises frames that include at least packetized information for coded speech data traffic, a requested data rate (RDR) for the coded speech data traffic, and a current data rate (CDR) for the coded speech data traffic, the data rate adjusting device comprising:

9A) data traffic-determining unit, operably coupled to receive packetized data traffic, for determining whether a current data rate (CDR) of the data traffic within the node exceeds a predetermined threshold and, where the CDR exceeds the predetermined threshold, determining an adjusted throughput data rate (ATDR) for communication links/station(s) utilizing the system in accordance with a predetermined strategy such that further links/station(s) may utilize the system;

9B) automatic adjusting unit operably coupled to the data traffic-determining unit for comparing the RDR of the frames with the ATDR, determining whether the RDR is greater than the ATDR and, where the RDR is greater than the ATDR, automatically adjusting the RDR downward to equal the ATDR,

such that a probability of call-blocking is reduced in the system,

and wherein each of the stations include:

9C) receiving-adjusting unit, operably coupled to a node, for, upon receiving the frame having packets of coded speech data traffic from the node, sending a received RDR to a transmission speech encoding-initializing unit of the station and decoding the packets at a rate defined by the CDR of the frame; and

9D) transmitting-adjusting unit, operably coupled to the node, for transmitting encoded speech packets, comprising:

9D1) encoding-initializing unit, operably coupled to receive digitized speech data input and to the receiving-adjusting unit, for encoding and packetizing the digitized speech data utilizing the CDR and for initializing an RDR of the frame to become substantially equivalent to the received RDR; and

9D2) data rate setting unit, operably coupled to the encoding-initializing unit, for setting the CDR to the RDR and inserting the CDR and RDR into the frame; and

9D3) transmitting unit, operably coupled to the data rate setting unit, for transmitting the frame to a preselected node.

10. The system of claim 9 wherein at least one of 10A-10B:

10A) the frames each further include a frame descriptor, and

10B) the predetermined strategy includes provision of an adjusted rate to the node where the adjusted rate is lower than the current rate and the ATDR is equivalent to one of 10B1-10B2:

10B1) a predetermined upper limit of the system's capacity; and

10B2) the predetermined upper limit of the system's capacity minus a predetermined buffer value.

FIG.1

100

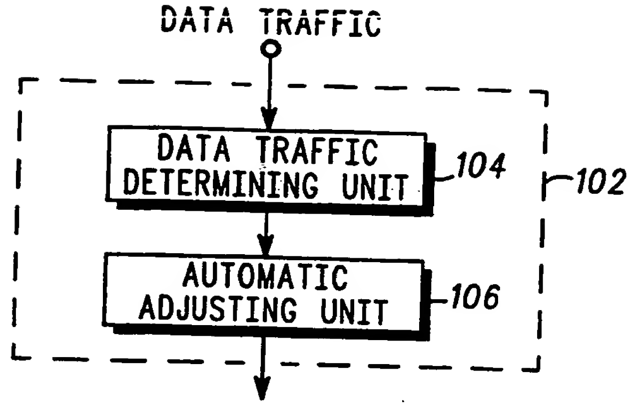
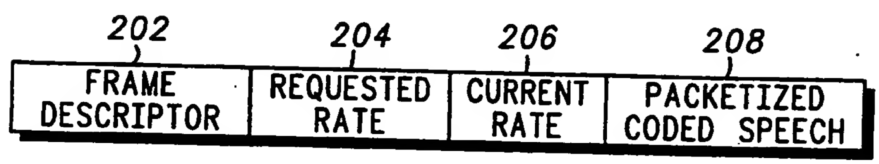


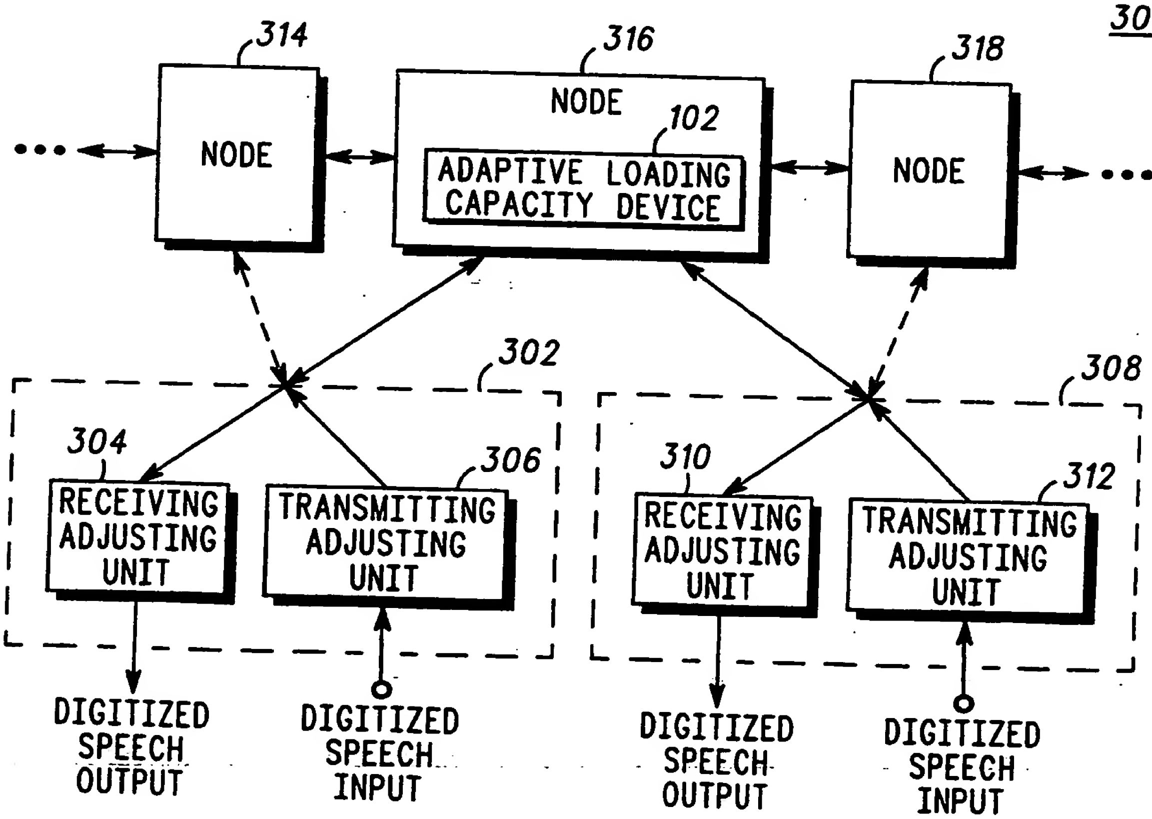
FIG.2



200

FIG.3

300



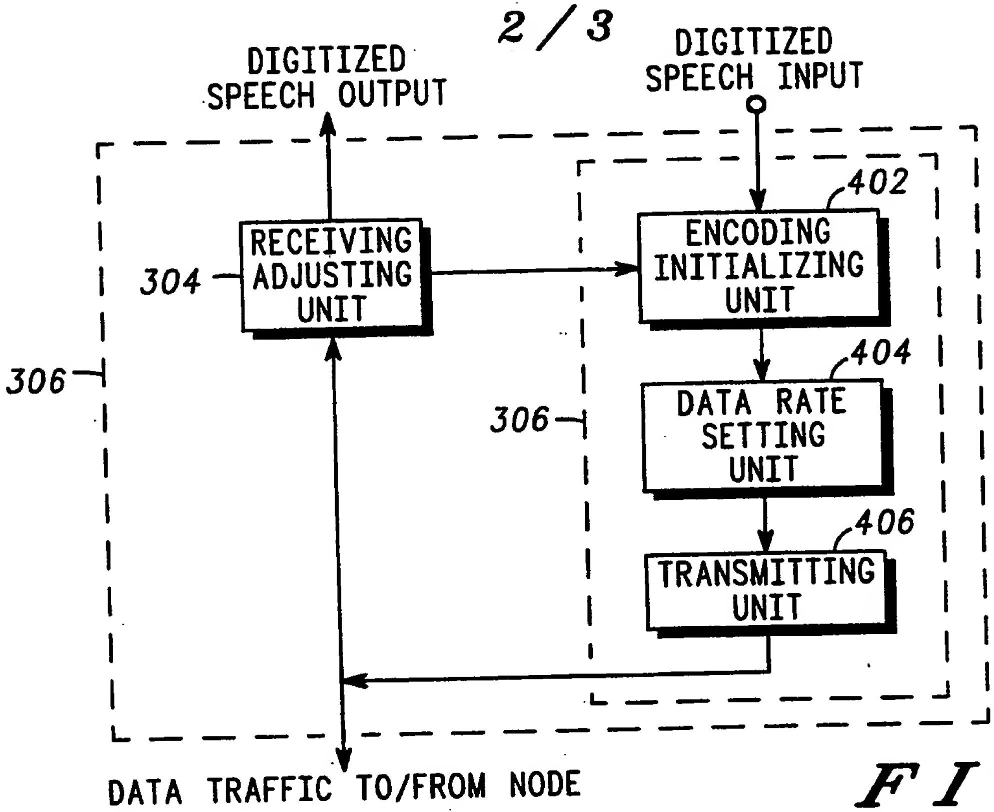


FIG.4

400

FIG.5

500

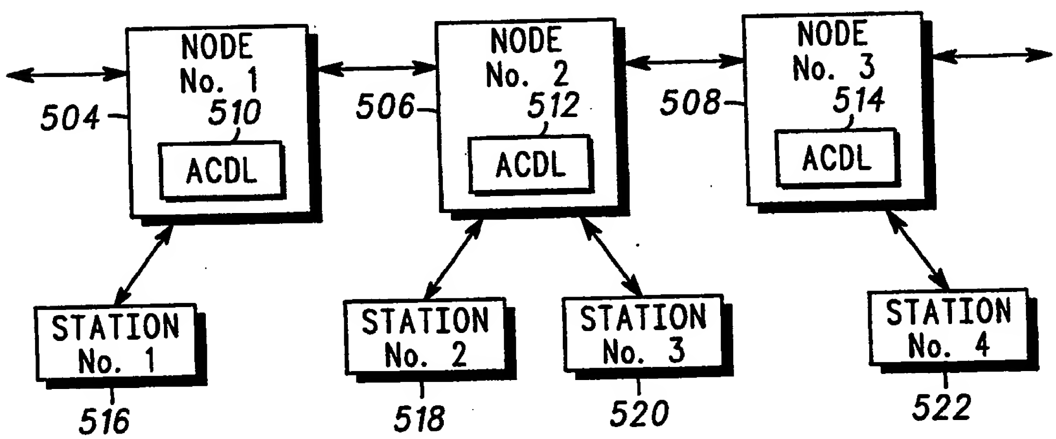
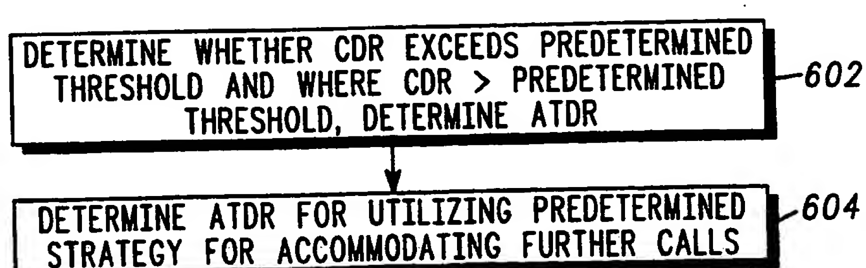


FIG.6

600



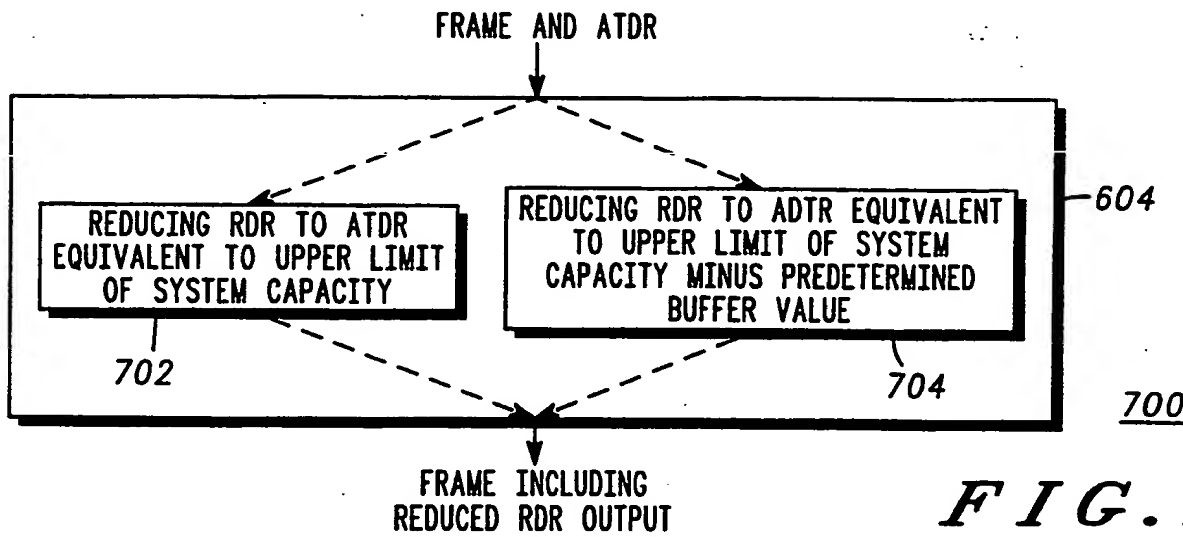


FIG.7

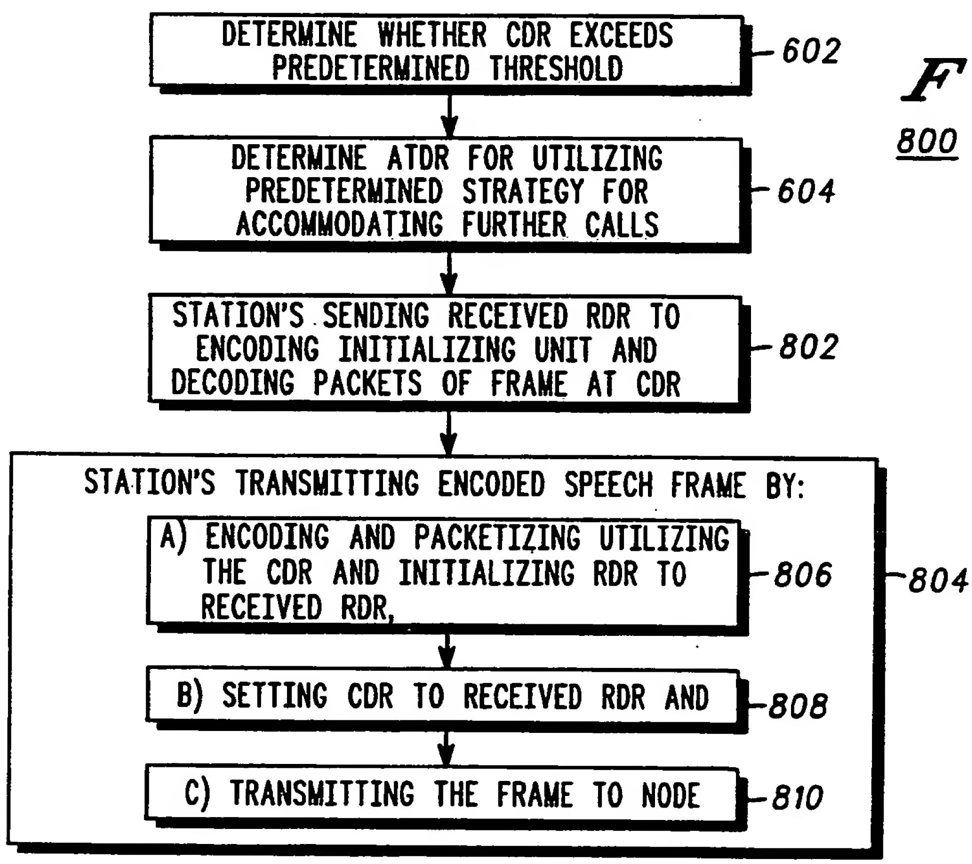


FIG.8

800

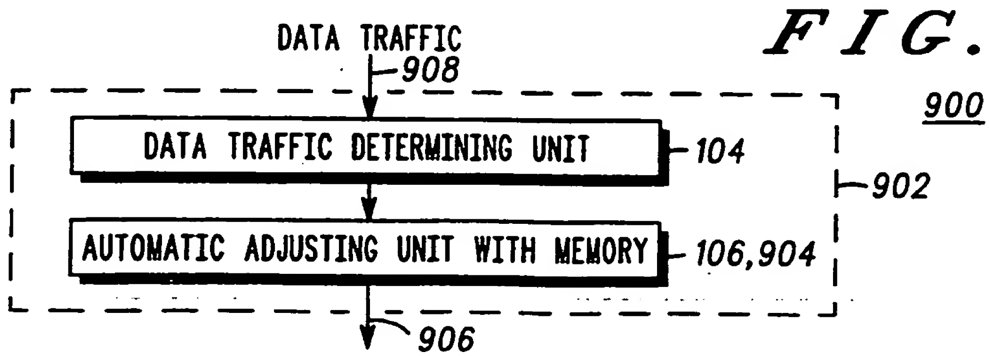


FIG.9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/11188

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :HO4J 3/22; HO4L 12/56
US CL :370/84, 94.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/60, 60.1, 79, 84, 94.1, 94.2, 94.3, 110.1, 118; 375/122; 381/30; 358/133,137, 138

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,100,377 (Flanagan) 11 July 1978, col. 3, line 59 through col. 4, line 17.	1, 5, 7, 9
A	US, A, 4,377,860 (Godbole) 22 March 1983, col. 1, lines 46-64.	1, 5, 7, 9
A	US, A, 5,115,429 (Hluchyj et al.) 19 May 1992, col. 4, line 43 through col. 7, line 57.	1, 3-5, 7, 9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search 24 January 1994	Date of mailing of the international search report MAR 04 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer HASSAN KIZOU Telephone No. (703) 305-4744